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Ethnomathematics: Challenging Traditional Notions of Mathematical Authority

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Challenging Traditional Notions of Mathematical Authority

by Christopher Goff

I am here today as an ambassador from the Western professional mathematical community. What follows are my views and opinions of Western mathematics, ethnomathematics, and mathematics education. Although I am not an expert on ethnomathematics, and although the actual subjects involved are more varied than this brief overview implies, I have tried to anticipate and answer the major questions. In order to help contextualize ethnomathematics, I will begin by briefly describing Western mathematics and mathematics education.

The Western development of mathematics has as its goal a purely abstract system of thought. It strives to be more theoretical than computational—more logic than number. This goal was formed concurrently with the field itself, over two thousand years ago in ancient Greece. In fact, the *Elements* was the most influential geometry text for two thousand years. In it, Euclid (c.325 – c.265 b.c.e.) reduced Geometry to five axioms, or postulates, and then proceeded to deduce geometric "truths" from these five basic assumptions. In reality, he made a few other implicit assumptions, but the structure of his work is still the structure of current mathematical writings.

During the twentieth century, mathematics proliferated in several different directions. In 1900, David Hilbert[1] (1862-1943) addressed the International Congress of Mathematicians in Paris, outlining his philosophy of mathematics and presenting 23 problems that would or should be answered in the upcoming century. This pivotal speech would ultimately spawn several new subfields within the discipline.[2] In 1931, Kurt Gödel (1906-1978) wreaked havoc on the logical underpinnings of mathematics when he showed that any mathematical system capable of performing basic arithmetic must be either logically inconsistent (having statements that are simultaneously true and false) or incomplete (having statements of indeterminable truth value).

Also in the twentieth century, statistics, the analysis of experimental data, began to emerge as a separate field of academic endeavor. Cryptology and number theory gained new utility from breaking codes in wartime to protecting credit card numbers on the internet. Fractals and chaos theory gained popularity, in part because they seemed harbingers of the demise of predictability in mathematics and in part because they provided countless breathtaking visuals used in computer animation. Despite such vastly different fields of study, there is still a common thread among "pure" mathematicians: the Euclidean format of definition, theorem, and proof.

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[1] Hilbert is sometimes referred to as the last mathematician to understand all the mathematics of his time.
[2] A quick search on MathSciNet for "Hilbert problem" reveals over 1600 papers.

Logical abstraction is a major goal of mathematics research; similarly, a major goal of mathematics education is to teach students how to use abstraction as a tool to organize their thoughts. Graduate students and advanced undergraduates in mathematics write many proofs as part of their learning process. Exactly when to introduce students to this abstract realm has been one of the topics of contention among mathematics educators over the years. Some may remember New Math,[3] the attempt in the 1960's to introduce the abstract nature of mathematics at an early age.

A common misconception about mathematics education, and one that the New Math initiative tried to change, is that mathematics is only learned by rote; countless drills and memorized algorithms equal mathematical knowledge. While such practices do improve proficiency and standardized test scores, they impart only ephemeral knowledge. Students who skip a year of mathematics often feel lost in their next mathematics class. It is better, then, to teach students how to think mathematically, how to solve problems creatively on their own. Ethnomathematics is part of this attempt to portray mathematics as a human endeavor, one that can be understood and applied to everyday life. In this regard, ethnomathematics represents a significant departure from the Western ideal of a contextless, abstract mathematics.

- What is ethnomathematics?

In 1985, ethnomathematics was defined by Ubiratan D'Ambrosio as "the maths practised among cultural groups such as national-tribal societies, labour groups, children of a certain age bracket, professional classes and so on."[4] Ron Eglash expands on this definition,[5] listing five recognizable subfields of ethnomathematics roughly in the order of their increasing distance from Western mathematics.

1) non-western [sic] mathematics. This consists primarily of historical studies of Chinese, Hindu, and Muslim civilizations. While early Chinese and Hindu civilizations are not usually considered part of the strict Western tradition, they did develop along parallel lines, making it somewhat easy to overlay the template of Western mathematics. The Arabic-speaking civilizations of Northern Africa, on the other hand, are part of the Western tradition, in that knowledge of algebra and geometry passed to Europe through northern Africa.[6]

2) mathematical anthropology. Scholars in this field apply mathematical analysis to patterns found within a culture, without the element of conscious intent. One

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[3] or the Tom Lehrer song of the same name
[4] "Ethnomathematics and Its Place in the History and Pedagogy of Mathematics." *For the Learning of Mathematics*, vol. 5, FLM Publishing Association, Canada, 1985.
[5] "When math worlds collide: intention and invention in ethnomathematics." *Science, Technology and Human Values*, v.22, no.1, pp.79-97, Winter 1997.
[6] Indeed, the word "algebra" comes from aljabr (restoring) and the word "algorithm" comes from the Arab mathematician al-Khwarizmi, who wrote the first algebra text.

example arises in the study of kinship systems in societies such as the Warlpiri of Australia's Northern Territory. Their society is divided into 8 groups with strict rules as to what group a spouse must come from and what group(s) the couple's children will go into. Westerners use abstract algebraic constructions to model this system.

3) sociology of mathematics. This involves studying the community of professional mathematicians using tools from Sociology. History of Mathematics is closely associated to this field.

4) vernacular mathematics. Here, mathematical ideas are found among people who are neither professional mathematicians nor members of an "ancient cultural tradition." Some examples include calculation techniques used by street vendors and the patterns found in quilts from various cultures.

5) indigenous mathematics. This field emphasizes the mathematical ideas of small-scale indigenous societies, with the element of conscious intent. Certain Native American views of space-time, strategy in the African game Oware[7] or the Maori game Mu Torere, and the different bases of various societies' number systems all constitute examples of indigenous mathematics.

- Why "multicultural" mathematics? Isn't math the same all over the world?

Claudia Zaslavsky, author of books like *Africa Counts: Number And Pattern In African Culture* and *The Multicultural Math Classroom: Bringing In The World*, responds to these common questions:

> It's true that people all over the world engage in mathematical activities…. They all count objects, they measure various quantities, they invent calendars…, they design works of art, they plan buildings, and they play games that involve mathematical concepts…. But each culture, each group, solves these problems in its own way.

She goes on to describe how the numerals we use today originated in India and passed through Northern Africa before reaching Europe. "Much of the foundation for the math that our children learn…was laid in Africa and Asia."

One common complaint is that students of ethnomathematics are not doing "real math." Senator Robert Byrd (D-West Virginia) recently criticized a specific Algebra textbook for its multicultural tendencies and, by extension, the inclusion of different cultural perspectives in mathematics education.

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[7] Oware, played in Ghana and Nigeria, is sometimes called Mankala, a more general term.

> This new-new mush-mush math will never produce quality engineers or mathematicians who can compete for jobs in the global market place…. This awful textbook obviously fails to do in 812 pages what comparable Japanese textbooks do so well in 200.[8]

Byrd refers to a textbook[9] that was sent to him by Marianne Jennings, Director of the Lincoln Center for Applied Ethics at Arizona State University and herself a critic of the incursion of multiculturalism into mathematics. In a piece for the *Wall Street Journal*,[10] Jennings dismisses the goal of conceptual understanding, instead likening the learning of mathematics to preparing a musical performance:

> The idea behind the [NCTM] standards[11] is that a "conceptual understanding" of math, not problems and practice, is what matters. It's like saying you can learn to play a piano concerto by studying how it's written – and forget about learning musical notation or even what a piano is.

Jennings later states that through memorization and rigor students can dominate mathematics and thereby gain a sense of self-worth.

> These standards fail to recognize that the memorization of basic math facts and the ability to do mental math are not only important skills, but predictors of future success…. Rigorous study of math, with all its challenges and eventual conquest, truly gives students what educators tout as all-important: self-esteem.

Clearly, Jennings and Byrd base their criticism on what they remember from their own mathematical upbringing, rather than on the current thinking of mathematics educators. The plug-and-chug methods they extol do not constitute rigorous mathematics. Nor can any success they may have enjoyed through unmotivated memorization be construed as proof that rote learning methods work for everyone.

- What are the pedagogical benefits to studying ethnomathematics in the classroom?

The main reason to include mathematics from other cultures is to make the subject more accessible. Many view Western mathematics as sterile and are turned off by its goal of complete abstraction. As it stands, mathematics effectively excludes people from many different populations. To wit, the current breakdown of American Mathematical Society (AMS) members by sex is 17% female and 83% male.[12] Of the 1119 Ph.D. recipients in

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[8] [Page: S5393] *Congressional Record*, United States Senate, June 9, 1997.
[9] "Secondary Math: An Integrated Approach: Focus on Algebra." Addison-Wesley.
[10] "MTV Math Doesn't Add Up." *Wall Street Journal*, December 17, 1996. Jennings wrote a similar piece in the *Christian Science Monitor* on the same textbook, dubbing it "Rain Forest Algebra."
[11] National Council of Teachers of Mathematics
[12] with no information on 14% of members

the 1999-2000 academic year, only 302 were women and only 70 listed their ethnicity as something other than Asian or White.[13] Allowing into the discussion mathematical topics from other cultures can help demystify the field of mathematics, thus bringing it to a wider audience. For example, Western mathematics has only recently begun to recognize contributions of Western women to the discipline. Notable among these have been:

1. Maria Gaetana Agnesi (1718-1799), who wrote an early calculus text[14];
2. Sophie Germain (1776-1831), whose work in number theory helped advance the frontier on Fermat's Last Theorem;
3. Florence Nightingale (1820-1910), who developed graphical representations of her observational data to bring about reforms in military hospital care;
4. Sofia Kovalevskaya (1850-1891), who, in addition to publishing in mathematical journals and gaining tenure at the University of Stockholm, also wrote plays, theater reviews, and treatises on women's rights; and
5. Emmy Noether (1882-1935), whose methods of studying abstract algebra still prove fruitful today.

Ethnomathematics also makes mathematics more interesting. Students naturally engage in mathematical activities: drawing designs with symmetry, playing games, counting. One way to teach would be to build upon these innate activities. In her book, *The Multicultural Math Classroom*, Zaslavsky describes the following examples of how works of literature have been used in elementary school mathematical activities.

Sadako and the Thousand Paper Cranes (Coerr 1977) recounts a fictionalized version of a true incident. Sadako, a Japanese girl, suffers from radiation poisoning incurred in the U.S. bombing of Hiroshima. When she hears that a sick person who makes a thousand paper cranes will be made healthy again, she and her family begin folding cranes. They are only able to complete 644 before Sadako dies. The participants, a group of children with their parents, then discussed the power of the story and its historical significance. Later, they learned how to fold paper cranes, and estimated how many were made each day of Sadako's illness. The Japanese art of *origami* can help students learn geometry by having them use manipulatives to discover properties of areas, angle measurements, bisection, and scale models. More advanced students can discuss the existence of folds with certain properties, such as the possibility of creating an equilateral triangle from a square piece of paper.

Another classroom activity involved quilts. Many cultures quilt, but Zaslavsky describes two books about quilting as it arises in the African American tradition. In *The Patchwork Quilt* (Flournoy 1985), Tanya, an African American girl, observes and later joins her mother and grandmother in their family's tradition of quilting. *Sweet Clara and the Freedom Quilt* (Hopkinson 1993) centers on a patchwork quilt containing a map to guide slaves along the Underground Railroad in their journey to freedom. Classroom activities involved counting how many squares were needed to make a certain quilt, measuring and

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[13] "2000 Annual Survey of the Mathematical Sciences." *Notices of the AMS*, vol.48, no.2, February 2001.
[14] A curve named for her is called the "Witch of Agnesi" due to a mistranslation of the original Italian.

cutting individual squares, assembling them into a quilt, and donating the finished product to a local retirement home. Possible extensions of these ideas include reconstructing the quilts described in the stories, cataloging various quilt patterns, analyzing symmetries found in sample quilts, and even discussing the role of mathematics in African American history.

- How does ethnomathematics establish the complementary natures of the sciences and the humanities as cultural authorities?

Mathematics is stereotypically viewed as the most extremely detached of the scientific cultural authorities. There is little room for interpretation of mathematical truths, and what room does exist is soon redefined away into new mathematical subdivisions. To many people, this kind of authority is frightening. There is some absolute sense of right and wrong and making a mathematical mistake leads some students to the misguided belief that they have failed in a fundamentally deep way.

Conversely, the humanities are stereotypically viewed as an antidote to the harsh mathematical realm. In the humanities, one is encouraged to create and justify one's own truths and to examine the elusive nature of truth from several different perspectives simultaneously. This kind of cultural authority rests on ground that is constantly shifting, which leads some students to the misguided belief that the humanities are capricious and irrelevant.

Indeed, straddling these two diverse cultural authorities may seem impossible. How can one have a relativistic sense of truth in the face of definitions, theorems, and proofs? On the other hand, how can one build a logical framework of mathematical knowledge on foundations as diverse as humankind? These disciplines are even attributed to separate halves of the brain, as if mathematics and the sciences lack creativity and the humanities lack logic. When phrased in the narrow language of stereotypical dichotomies, any sort of compromise seems doomed to fail.

Ethnomathematics offers a means to bring about an effective synthesis of these competing cultural authorities by expanding on each of the stereotypes and rephrasing the dichotomy altogether. For example, ethnomathematics highlights the "truth" that mathematics is a social construct simply by studying the mathematics of other societies. This effectively demonstrates the tremendous Western influence on today's mathematical world. Mathematicians willing to entertain the notion of their own partiality will be forced to examine the authority of mathematics within a strict cultural framework. Moreover, American Studies scholars employing methods from Ethnic Studies or Cultural Studies can use ethnomathematics as a way to approach mathematical ideas within the context of their own disciplines.

There are examples of unique mathematics, even difficult (Western) mathematical concepts, in indigenous cultures and urban societies. These concepts stimulate the interest of professional (Western) mathematicians. One facet of ethnomathematics leads toward assimilating these concepts into current mathematical research. Conversely, the professional in Cultural Studies might be interested in the very presence of these concepts: how they came into being, and how Western mathematics developed as a construct of its own society. Another facet of ethnomathematics examines mathematicians as a social class and their mathematics as a social construct. Thus, ethnomathematics can stimulate rewarding avenues of inquiry for both mathematicians and Cultural Studies professionals. If nothing else, ethnomathematics removes mathematics from its self-acclaimed position of supremacy in computational expertise and logical abstraction and places it in a more realistic social context, one that is subject to the same investigative tools as other social creations.

As Marcia Ascher explains in her book, *Ethnomathematics*, "[M]athematical ideas are an important aspect of what it means to be human." Focusing on common human origins can help us transcend the differences between the sciences and the humanities, thus fostering a new discussion about the intermingling roles of these truly complementary cultural authorities.